

VEHICLE ELECTRICAL SYSTEM INCLUDING BATTERY STATE OF CHARGE
DETECTION ON THE POSITIVE TERMINAL OF THE BATTERY

Field of the Invention

The present invention relates to a vehicle electrical system, and relates more particularly to a vehicle electrical system that includes an arrangement for detecting battery state-of-charge on the positive terminal of the battery.

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Background Information

A method of compensating for measuring error in detecting current in an energy storage device is known from, e.g.,
10 published German Patent Application No. 100 01 340. In the method disclosed in this document, the current is detected using two current converters that are situated on the lead running from the positive terminal of the battery to a generator and the consumers. The current converters deliver
15 their particular output signal to an electronic evaluation unit having a correction stage. At the output of the electronic evaluation unit, corrected measured values corresponding to the battery current are supplied.

20 Also known in the art are back-up fuse boxes, which are connected to the positive terminal of a vehicle battery and are used for the distribution of power and fuse protection of leads and connected loads in the vehicle electrical system. Such a back-up fuse box provided in the vehicle usually
25 contains screwable or plug-in fuses.

Control units for power management are also known in the art, which are situated between the negative terminal of the battery of a motor vehicle and ground. The battery current is detected in the area of the negative terminal. In this arrangement, a connection leading from the battery to the control unit and another connection leading from the control unit to the vehicle ground are necessary.

Furthermore, energy supply systems provided in modular form for a motor vehicle are known in the art, e.g., from the journal Auto Technology, April 2001, pages 82-85. Modules provided in these power supply systems contain relays, fuses and electronic components that control the current flow in the electrical supply system. These modules include, for example, back-up fuse boxes that protect the main branches of the power system, as well as fuse and relay boxes that protect downstream systems and switch loads (or groups of loads) on and off.

Summary of the Invention

In accordance with the present invention, an integrated module is provided to function as a central, intelligent electrical power coordinator of a vehicle. The loads of the electrical system are supplied via this module. The direct connection of the module to the positive terminal of the vehicle battery makes it possible to use the module for detecting the battery state of charge, since the variables necessary for battery state-of-charge detection are available at the module. The negative terminal of the battery may be connected directly to ground, since the control unit provided between the negative terminal of the battery and ground in conventional systems is not present. Significant advantages result from this arrangement in accordance with the present invention in terms of cost and operation, since the resistance in the ground wire

between the negative terminal of the battery and vehicle ground is not increased by additional bridging resistances that arise when a control unit is incorporated into the conventional arrangement.

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In accordance with the present invention, fuses may be provided between the positive terminal of the battery and the supply leads within the module leading to the loads, the state of the fuses being monitored and considered by the control unit for electrical power management. In addition, the control unit is connected to an arrangement for detecting battery state-of-charge, thereby being able to consider the state of charge of the battery in distributing the power in the motor vehicle.

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In accordance with the present invention, the control unit for electrical power management may be connected to additional control units of the motor vehicle via bus connections and to loads for the purpose of data exchange. In this manner, it is possible to include the additional control units and consumers in the electrical power management.

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It is also possible to use the control unit for electrical power management to interrupt and close leads routed to specific loads (or leads routed to load groups) using a circuit breaker also situated within the module. This makes it possible, for example, to perform a closed-circuit current cutoff in a case of a fault, as well as to perform a disconnection of an entire electrical system area for servicing, transporting, or temporarily shutting down the vehicle. Furthermore, in the event of an accident, an entire electrical system area may be disconnected from the battery. This ensures that in the event of a short-circuit in the vehicle electric system caused by an accident, no cable fire will ensue. Furthermore, circuit breakers or battery master

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switches may be situated within the module in the path of the lead routed to the vehicle generator and in the path of the lead routed to the starter. Consequently, such components need no longer be mounted externally, which results in a cost savings.

Brief Description of the Drawings

Figure 1 shows a block diagram of a first exemplary embodiment of the present invention.

Figure 2 shows a block diagram of a second exemplary embodiment of the present invention.

Figure 3 shows a block diagram of a third exemplary embodiment of the present invention.

Figure 4 shows a block diagram of a fourth exemplary embodiment of the present invention.

Figure 5 shows a block diagram of a fifth exemplary embodiment of the present invention.

Figure 6 shows a block diagram of a sixth exemplary embodiment of the present invention.

Figure 7 shows a block diagram of a seventh exemplary embodiment of the present invention.

Detailed Description

In Figure 1, which shows a block diagram of a first exemplary embodiment of the present invention, the vehicle electrical system shown includes a battery 1 having a positive terminal and a negative terminal. The negative terminal of the battery

is connected to ground. A module 2 is connected directly to the positive terminal of battery 1. This module has an integrated electronics unit, which includes means 3 for detecting the state of charge of the battery, a control unit 4 for the power management of the vehicle electrical system, a unit 5 for the diagnosis and regulation of a generator, a battery master switch 6, a DC-DC converter 7 and fuses Si1 - Si4.

The fuses Si1 - Si4 are each connected to a supply output of module 2, a circuit breaker 8 being provided between fuse Si2 and the associated supply output of module 2, and a circuit breaker 9 being provided between fuse Si1 and the associated supply output of module 2. Battery master switch 6 and the two circuit breakers 8 and 9 are each activated by control unit 4 for power management and opened and closed as needed during operation of the vehicle.

Loads V_1 , V_2 and V_3 are connected to the supply outputs of module 2 assigned to fuses Si1, Si2 and Si3. An additional consumer 10, which may be an electrohydraulic brake or an electric steering system, for example, is connected to the output assigned to fuse Si4.

The terminal of battery master switch 6, which is remote from battery 1, is connected to an additional terminal of module 2, to which starter S of the motor vehicle is connected via a starter relay 11 and generator 13 of the motor vehicle is connected via an external fuse 12. Generator 13 is connected to a regulator 14 which, in turn, is in contact with unit 5 (provided within module 2) for diagnosis and regulation of the generator, via a bit synchronized interface BSS.

Means 3 for battery state-of-charge detection includes a battery current meter, a battery voltage meter and a battery

temperature meter. The battery current meter measures the battery current using either Hall sensors, one or more current converters, or a current shunt. As part of this battery current measurement, the entire battery current is recorded, i.e., both the current flowing into the battery and the current flowing out of the battery. The battery voltage $u(t)$ and battery temperature $\delta(t)$ are measured using external sensors, which provide information concerning the battery voltage or the battery temperature, respectively. From the measured battery current, the measured battery voltage and the measured battery temperature, a signal describing the battery state of charge is determined, which is provided to control unit 4 for electrical power management. As an additional input signal, control unit 4 receives diagnostic signals obtained from one or more of fuses Si1, Si2, Si3 and Si4, which signals describe the state of the particular fuses.

As a function of the state signals supplied to the control unit 4, the control unit 4 performs the electrical power management of the electrical system. To this end, the control unit 4 may, for example, change the state of battery master switch 6, of circuit breaker 8, and of circuit breaker 9. If, for example, the control unit 4 detects the presence of a weak battery based on the battery state-of-charge signals, the control unit 4 then disconnects the loads whose function is not essential to the safety of the motor vehicle. The loads that are not essential for the safety of the motor vehicle include, for example, the rear window de-mister.

Furthermore, control unit 4 communicates via a vehicle bus, e.g., a CAN data bus or a LIN data bus, with other control units of the vehicle and/or individual loads, load V_1 , for example. As part of this communication, control unit 4 is able to send information to the other components concerning the energy state of the vehicle electrical system, which the

particular components implement in a suitable form, for example, to the end of reducing the energy consumption occurring there.

5 Control unit 4 is also connected to unit 5 for diagnosis and regulation of generator 13, and the control unit 4 is therefore also able to consider information concerning the state of the generator for electrical power management, as well as initiate a regulation of the generator, based on which
10 the state of charge of the battery is rapidly increased again in the event of a weak battery.

Using DC-DC converter 7, which is also situated within module 2, the supply voltage derived from battery 1 is converted into
15 another supply voltage U2, which is needed by additional consumers not shown in Figure 1.

In accordance with the present invention, the above-described integration of electronic components into module 2, which
20 forms a back-up fuse box, provides significant improvement of functionality over the conventional back-up fuse boxes, which means significant customer benefit. The above-described integration of electronic components for detecting the battery state of charge and for providing power management in one
25 back-up fuse box provides a significant advantage because the back-up fuse box in accordance with the present invention is located in the vicinity of the battery, where state variables such as battery current, battery voltage and battery temperature are available. Moreover, with the integrated
30 back-up fuse box located in the vicinity of the battery, it is possible to perform a control and diagnosis of power flow paths, fuses, circuit breakers, etc., in connection with power management.

The use of a back-up fuse box as an installation site for the above-described integrated electronic unit eliminates the necessity for an additional control unit to be installed in the vehicle. This is a great advantage with respect to costs and required space.

The present invention also addresses the fact that the selection of electrical loads in motor vehicles is constantly increasing, e.g., safety-relevant consumers such as an electrohydraulic brake or electric power-assisted steering. The described integration of a battery state-of-charge detector and power management in one back-up fuse box connected to the positive terminal of the battery makes it possible to increase the reliability of the electrical system through intelligent activation and deactivation of consumers and a control of the charge or discharge operation of the battery.

The use of a battery master switch, which is situated within the module (which forms a back-up fuse box), also makes it possible, for example, to protect a starter lead in vehicles that have a battery located in the rear.

Figure 2 shows a block diagram of a second exemplary embodiment of the invention. The vehicle electrical system shown in Figure 2 includes a battery 1 having a positive terminal and a negative terminal; the negative terminal is connected to ground. A module 2, which is connected directly to the positive terminal of battery 1, has an integrated electronics unit, which includes means 3 for detecting the battery state of charge, a control unit 4 for the power management of the vehicle electrical system, a unit 5 for the diagnosis and regulation of a generator, a starter relay 11 and fuses Si1 - Si5.

Fuses Si1 - Si4 are each connected to a supply output of module 2. A circuit breaker 8 is provided between fuse Si2 and the associated supply output of module 2, and a circuit breaker 9 is provided between fuse Si1 and the associated supply output of module 2. The two circuit breakers 8 and 9, as well as starter relay 11, are each activated by control unit 4 for power management and opened and closed as needed during operation of the vehicle.

Loads V_1 , V_2 and V_3 are connected to the supply outputs of module 2 assigned to fuses Si1, Si2 and Si3. An additional load 10, which may be an electrohydraulic brake or an electric steering system, is connected to the output assigned to fuse Si4.

The terminal of fuse Si5, which is remote from battery 1, is connected to an additional terminal of module 2, to which generator 13 of the motor vehicle is connected. Generator 13 is also connected to a regulator 14 which, in turn, is in contact with unit 5 for the diagnosis and regulation of the generator provided within module 2, via a bit synchronized interface BSS. The terminal of starter relay 11, which is remote from battery 1, is connected to starter S, and one terminal of the starter is connected to ground.

Means 3 for detecting the battery state of charge includes a battery current meter, a battery voltage meter and a battery temperature meter. The battery current meter measures the battery current using Hall sensors, one or more current converters, or a current shunt. As part of this battery current measurement, the entire battery current is recorded, i.e., both the current flowing into the battery and the current flowing out of the battery. The battery voltage $u(t)$ and battery temperature $\delta(t)$ are measured using external sensors, which provide information concerning the battery

voltage or the battery temperature, respectively. From the measured battery current, the measured battery voltage and the measured battery temperature, a signal describing the battery state of charge is determined and provided to control unit 4 for electrical power management.

As a function of the state signals supplied to the control unit 4, the control unit 4 performs the electrical power management of the electrical system. To this end, the control unit 4 may, for example, change the state of starter relay 11, of circuit breaker 8 and of circuit breaker 9. If, for example, control unit 4 detects the presence of a weak battery based on battery state-of-charge signals, it then disconnects the loads whose function is not essential to the safety of the motor vehicle, e.g., the rear window de-mister.

Furthermore, control unit 4 communicates via a vehicle bus, e.g., a CAN data bus, with other control units of the vehicle and/or with load 10, for example. As part of this communication, control unit 4 is able to send information to the other components concerning the energy state of the vehicle electrical system, and the particular components utilize the information in a suitable manner, e.g., to the end of reducing the power consumption occurring there.

Control unit 4 is also connected to unit 5 for diagnosis and regulation of generator 13. Accordingly, the control unit 4 is therefore also able to consider information concerning the state of the generator for electrical power management and also initiate a regulation of the generator, based on which the state of charge of the battery is rapidly increased in the event of a weak battery.

In the exemplary embodiment shown in Figure 2, in contrast to the embodiment shown in Figure 1, starter relay 11 and fuse

Si5 provided between the battery and generator 13 are also situated within module 2. This results in additional advantages, e.g., a simplified activation of starter relay 11. Another advantage is that it is not necessary to install fuse Si5 and starter relay 11 as additional external components.

Figure 3 shows a block diagram of a third exemplary embodiment of the present invention. The vehicle electrical system shown in Figure 3 includes a battery 1 having a positive terminal and a negative terminal. The negative terminal of the battery is connected to ground, and a module 2 is connected directly to the positive terminal of battery 1. The module 2 has an integrated electronics unit, which includes means 3 for detecting battery state of charge, a control unit 4 for the power management of the vehicle electrical system, a unit 5 for the diagnosis and regulation of a generator, a circuit breaker 6 and fuses Si1 and Si2.

These fuses Si1 and Si2 are each connected to a supply output of module 2. Loads V_1 and V_2 are connected to the supply outputs of module 2 assigned to fuses Si1 and Si2. Circuit breaker 6 is activated by control unit 4 for power management and is opened and closed as needed during operation of the vehicle. The terminal of circuit breaker 6, which is remote from battery 1, is connected to an additional terminal of module 2, to which starter S and generator G of the motor vehicle are in turn connected.

Means 3 for battery state-of-charge detection, control unit 4 for electrical management, and unit 5 for diagnosis and regulation of the generator operate just as described above in connection with Figures 1 and 2.

A feature that should be noted in the exemplary embodiment shown in Fig. 3 is the integration of circuit breaker 6 into

module 2, which is a back-up fuse box. The circuit breaker shown in Figure 3 may be opened automatically in case of an accident, e.g., in order to avoid the occurrence of a cable fire in the event of a short-circuit.

Figure 4 shows a block diagram of a fourth exemplary embodiment of the present invention. The vehicle electrical system shown in Figure 4 includes a battery 1 having a positive terminal and a negative terminal. The negative terminal of the battery is connected to ground, and a module 2 is connected directly to the positive terminal of battery 1. The module 2 has an integrated electronics unit, which includes means 3 for battery state-of-charge detection, a control unit 4 for the power management of the vehicle electrical system, a unit 5 for the diagnosis and regulation of a generator, a circuit breaker 6 and fuses Si1-Si4.

Fuses Si1-Si4 are each connected to a supply output of module 2. Circuit breaker 6, which is activated by control unit 4 for power management and is opened and closed as needed during operation of the vehicle, is situated between a first set of fuses Si1, Si2 and a second set of fuses Si3, Si4 in such a way that fuses Si1 and Si2 are also connected to the battery when the circuit breaker is open, while fuses Si3 and Si4 are disconnected from the battery when circuit breaker 6 is open.

Loads V_1 and V_2 are connected to the supply outputs of module 2 assigned to fuses Si1 and Si2. Loads V_3 and V_4 are connected to the supply outputs of module 2 assigned to fuses Si3 and Si4. Consequently, loads V_3 and V_4 are disconnected from the battery when circuit breaker 6 is open, while loads V_1 and V_2 continue to be supplied with power.

The terminal of circuit breaker 6 which is remote from battery 1, continues to be connected to an additional terminal of

module 2, to which starter S of the motor vehicle and generator G of the motor vehicle are connected.

Means 3 for battery state-of-charge detection, control unit 4 for electrical management, and unit 5 for diagnosis and regulation of the generator operate as described above in connection with Figures 1 and 2.

A feature of this exemplary embodiment that should be noted is the integration of circuit breaker 6 into module 2, which is a back-up fuse box. The circuit breaker shown in Figure 4 may be opened automatically in case of an accident, e.g., in order to avoid the occurrence of a cable fire in the event of a short-circuit. Moreover, in the event of a fault, or for transport or service, the circuit breaker may also be opened for closed-circuit current cutoff. In addition, since the circuit breaker is located between the battery and the starter, as well as between the battery and the generator, the circuit breaker carries the starter current and may also be used for protection of the otherwise unprotected starter/generator lead.

In addition to the above, positioning fuses Si1 and Si2 upstream of circuit breaker 6 ensures the power supply of loads V_1 and V_2 even when circuit breaker 6 is in open position. Loads V_1 and V_2 may be critical loads, i.e., components that must not be disconnected from the battery.

In the exemplary embodiment of Fig. 4, it is consequently possible to disconnect one group of loads from battery 1 by opening circuit breaker 6, while another group of loads continues to be supplied with power.

Figure 5 shows a block diagram of a fifth exemplary embodiment of the present invention. The vehicle electrical supply

system shown in Figure 5 differs from the one shown in Figure 4 in that a separate circuit breaker integrated into module 2 is assigned to starter S. In the exemplary embodiment shown in Figure 5, generator G is connected to the battery via circuit breaker 6, with an additional fuse Si5 being provided between circuit breaker 6 and generator G. Like circuit breaker 6, this fuse Si5 is also a component of module 2.

It is possible to use circuit breaker 6 to disconnect load groups and component groups at the highest electrical system level in the event of an accident, e.g., to prevent a cable fire in the event of a short-circuit or for the purpose of a closed-circuit current cutoff in the event of a fault, or for transport or service. Circuit breaker 11 is used to switch and protect the starter lead, and circuit breaker 11 may, for example, replace the primary relay integrated in the starter and thus cut off voltage to the starter lead.

A power supply to the critical loads or the components that must not be disconnected from the battery is also ensured in this exemplary embodiment in that these loads are situated between the battery and circuit breaker 6 so that they are connected to battery 1 even when circuit breaker 6 is open.

Figure 6 shows a block diagram of a sixth exemplary embodiment of the present invention. This exemplary embodiment differs from the previous exemplary embodiments in that module 2 has only a single supply output to which a fuse box 15 is connected. The primary supply lead is subdivided into three load supply leads in fuse box 15, and a fuse Si1, Si2 or Si3 is situated in each of these load supply leads. Fuse box 15 has three supply outputs. Load V_1 is connected to the first supply output, load V_2 is connected to the second supply output, and load V_3 is connected to the third supply output.

Figure 7 shows a block diagram of a seventh exemplary embodiment of the present invention. This embodiment is substantially similar to the exemplary embodiment shown in Figure 1, but differs from the embodiment of Fig. 1 in that the starter and generator leads are exclusively protected via circuit breaker 6, and in that external protection measures are omitted.